



POSTER PRESENTATION

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# Compressed sensing cardiac MRI exploiting spatio-temporal sparsity

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## Background

Compressed Sensing (CS) is a theory with potential to reconstruct sparse images from a small number of random acquisitions. Particularly in MRI, CS aims to reconstruct the image from incomplete K-space data with minimum penalty on the image quality. The image is recovered from the sub-sampled K-space data, using image sparsity in a known sparse transform domain. Cardiac MRI has a sparse structure in both temporal and spatial domains; making CS a promising method for such application.

## Methods

Experiments were performed on a data set acquired by Cagdas Bilen *et al.*[1]. Fully sampled data were acquired using a 128×128 matrix (FOV = 320 × 320 mm) and 23 temporal frames covering the cardiac cycle. In this study, we reconstructed eight (one in every three) frames through CS using Gradient Projection for Sparse Reconstruction (GPSR) algorithm. The remaining 15 frames were reconstructed through a combination of CS and temporal information (TI). Sampling rate for the CS and CS-TI frames was set to 0.5 and 0.3, respectively. Block Discrete Cosine Transform (BDCT), Block Walsh-Hadamard Transform (BWHT) and Gaussian Transform were used to create measurement matrix in CS. Discrete Wavelet Transform (DWT) was used as sparse basis. The fidelity term in cost function is modified as:  $g=0.9||$

$Fu - y||^2 + 0.1||TE - m||^2$ , where  $Fu$  represents the under-sampled Fourier operator,  $y$  represents the K-space under-sampled data, and  $TE$  (Temporal Estimation) represents the obtained frames from TI. In this study, we use interpolation (I), forward motion estimation (FME) and forward-backward motion estimation (F-B ME), respectively on previous and next CS frames to obtain TI.

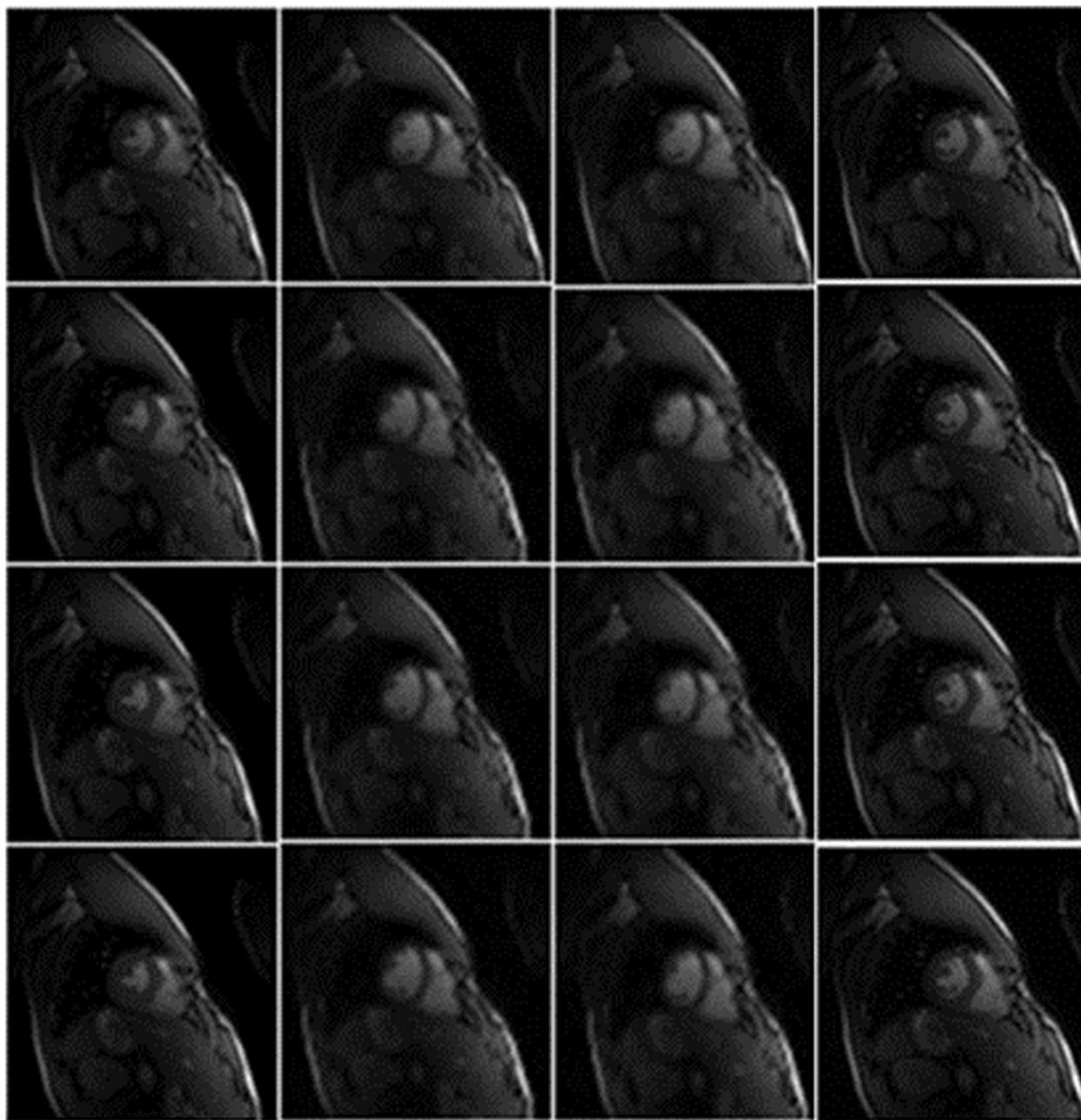
## Results

Figure 1 illustrates one frame from the original set along with the corresponding CS and CS-TI frames reconstructed with proposed methods for TI generation. Table 1 shows numerical results including SNR, PSNR, Structural SIMilarity (SSIM) and computational time for each proposed method.

## Conclusions

The proposed method increased under-sampling rate and expedited reconstruction time in CS theory. The results were quantified using SNR, PSNR and SSIM for the quality of the reconstruction and the computational time, concluding that BWHT outperforms other methods in both quality measures and computational time with 15% and 10%, respectively. In all aforementioned a derivative of the proposed method, the processing time was at least 4 times accelerated compared to the routine CS algorithm.

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**Figure 1** From left to right, First row) original image, CS frame with BWHT, BDCT and Gaussian measurement matrices. Second row) CS-TI using l1 method frame with BWHT, BDCT and Gaussian measurement matrices. Third row) CS-TI using FME method frame with BWHT, BDCT and Gaussian measurement matrices. Fourth row) CS-TI using (F-B) ME method frame with BWHT, BDCT and Gaussian measurement matrices.

**Table 1 Results Of Proposed Methods Show That BWHT Outperform Other Methods.**

Measurement Matrix	methods	TI - Methods	SNR	PSNR	SSIM	Time(s)
BWHT	CS-TI	CS	26.750626	82.80	0.981008	11.3048
		l1	28.076336	83.82	0.983096	2.5165
		FME	27.796233	83.88	0.974924	2.1939
		F-B ME	27.946202	83.93	0.979615	2.3913

**Table 1 Results Of Proposed Methods Show That BWHT Outperform Other Methods. (Continued)**

Gaussian	CS	I	21.545575	75.25	0.827131	12.1182
			22.505806	76.34	0.780809	2.9337
	CS-TI	FME	20.527749	72.95	0.791594	2.9910
			21.586516	76.32	0.805057	3.0172
BDCT	CS	I	26.985696	82.07	0.974128	12.6598
			27.656441	83.16	0.958932	2.8911
	CS-TI	FME	27.720514	83.87	0.977975	2.3867
			29.923755	83.86	0.962291	2.1828

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#### Reference

1. Bilen C, Wang Y, Selesnick I: **High Speed Compressed Sensing Reconstruction in Dynamic Parallel MRI Using Augmented Lagrangian and Parallel Processing**. 2012, arXiv preprint arXiv: 1203.4587.

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